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16. Abstract

The goal of this study was to provide information about the frequency of installation and use of fog lamps. Two surveys were performed. In the first one, installation of fog lamps was estimated by a survey of parked vehicles in two large shopping centers. The second survey studied the usage of fog lamps during daytime and nighttime, under clear, rainy, or foggy conditions. In this survey, an observer in a moving vehicle noted the types of lamps that were energized on the fronts of oncoming vehicles, and whether fog lamps were installed at all. The main findings are:

(1) The best estimate of the current frequency of installation of fog lamps in southeast Michigan is about 13%.

(2) During daytime, the usage of fog lamps increased with deterioration in atmospheric conditions, with the usage reaching 50% of all installed fog lamps during moderate-to-heavy fog. This indicates that, during daytime, drivers adjust the usage of their lamps in response to atmospheric conditions, probably more to increase the conspicuity of their own vehicle than to illuminate the road ahead.

(3) During nighttime, the usage of fog lamps was rather high (around 63% of fog lamps installed). However, the usage does not appear to be influenced by the presence of fog or rain. This implies that, during nighttime, fog lamps are used to supplement low beams in general, rather than to provide lighting adapted to atmospheric conditions.

(4) When fog lamps were used during daytime, they were seldom used alone, without standard headlamps. During nighttime, fog lamps were never used alone. This pattern of nighttime usage is consistent with the Society of Automotive Engineers Standard J583, and with the intent of the laws of the State of Michigan. However, this pattern of usage might limit the potential benefits that could be achieved in heavy fog with well-designed fog lamps used without standard headlamps.

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Introduction

Fog during nighttime reduces the contrast of objects in a driver's visual field. Water particles in the fog absorb and scatter light from headlamps. This leads to a reduction in the light reaching objects in the roadway, and to the formation of a luminous veil over the objects and their background (back scatter). Comprehensive reviews of the issues related to driving in fog are provided by Moore and Cooper (1971), Behrens and Kokoschka (1976), and Koth, McCunney, Duerk, Janoff, and Freedman (1978).

To assist drivers in fog, special fog lamps have been used at least since 1926 (Koth et al., 1978). In comparison with low-beam headlamps, fog lamps have (1) lower peak illumination, (2) more stringent limits on illumination above horizontal, (3) wider horizontal spread of the illumination, and (4) lower mounting height.

Koth et al. (1978), in their review of usage recommendations, found that there is not complete agreement on whether fog lamps should be used with, rather than instead of, low beams during nighttime fog. On the other hand, there seems to be a general consensus that low beams should not be turned off unless the fog is heavy. For example, Autocar (1972) recommends that when the fog is light, only low beams should be used; in medium fog low beams and fog lamps should be used; and in heavy fog only fog lamps should be used. Hisdal (1974) goes even further in recommending that fog lamps should not be used at all in light or medium fog, because the use of fog lamps in addition to the low beams would increase the glare for oncoming traffic and reduce the visibility in front of one's own vehicle. Hisdal recommends that the use of fog lamps alone be reserved for heavy fog only.

The use of fog lamps during nighttime fog serves two functions: improved visibility in front of one's own vehicle, and improved signaling of presence to oncoming traffic. On the other hand, during daytime fog, the only consideration is to increase the evidence of one's presence. Consequently, most authors recommend against the use of fog lamps during daytime fog, but recommend instead the use of low beams or even high beams (Koth et al., 1978).

Optimal design of fog lamps depends on whether the fog lamps are to be used with, or instead of, standard headlamps. The desirable beam pattern and mounting height of fog lamps will be different if they are used in cooperation with standard headlamps rather than if they are used alone, in which case they need to perform some of the functions currently performed by standard headlamps.

The Society of Automotive Engineers (SAE) Standard J583 (Society of Automotive Engineers, 1993) is clear in indicating that fog lamps are to be used in

conjunction with standard low beams. The standard states that "principally, the front fog lamp supplements the lower beam of a standard headlamp system." In the U.S., the actual usage of fog lamps is regulated by state laws, and in many cases the laws prohibit the use of fog lamps during nighttime without the use of standard headlamps. The situation in Michigan is governed by the Michigan Vehicle Code (1995). While the language in the Code is not explicit, it appears that it mandates the use of standard headlamps when visibility is reduced to less than 152.4 m (500 feet) (§257.684, §257.685, and §257.696). An additional constraint on drivers' usage of fog lamps is that in the U.S. the wiring on many vehicles prevents turning on fog lamps without turning on standard headlamps.

Data on actual usage of fog lamps are limited. The only published data that we are aware of is from Norway (Hisdal, 1974). In that study, nighttime observations were made in and around the capital city of Oslo, during light fog on roads with street lighting. Hisdal reports that on sections with poor street illumination “up to 5% of all cars had the fog lamps on in addition to the low beams” (p. 2). This number dropped to 2% on a section with good street illumination.

The present study was designed to provide estimates about the installation rates and usage of fog lamps in the U.S. The issue of installation rates was addressed primarily by a survey of vehicles parked in the parking lots of two large shopping centers. The issue of usage was addressed by observing oncoming traffic during daytime and nighttime, under one of three atmospheric conditions (clear, rain, and fog). Of additional interest was whether when fog lamps are used, they are used alone or in conjunction with standard headlamps.

Survey 1: Installation of fog lamps

Method

The survey was performed in the parking lots of two large shopping centers in Ann Arbor—a city in southeast Michigan with a population of about 120,000. By reputation, Center 2 is frequented by more affluent customers, who may drive newer and more expensive vehicles. The vehicles in this survey included cars, vans, and pick-up trucks. The two shopping centers were surveyed during daylight hours on one weekday per each center in June 1996.

A lighting engineer with eight years of vehicle lighting experience examined the fronts of parked vehicles and noted whether they were equipped with fog lamps.

Results

Table 1 shows the percentage of vehicles equipped with fog lamps, broken down by the two shopping centers surveyed. There was a higher percentage of fog lamps in Center 2. Based on these results, the frequency of fog lamps in southeast Michigan is likely to be between 10% and 20%. (Additional information on this issue is provided by Survey 2.)

Table 1
Percentage of Vehicles Equipped with Fog Lamps.

Shopping Center	Number of Vehicles Surveyed	% of Vehicles with Fog Lamps
1	394	9.9
2	738	21.5

Survey 2: Usage of fog lamps

Method

Procedure. This survey was performed from a moving vehicle. The coding was done by a lighting engineer with three years of headlighting experience.[1] For each oncoming vehicle, this experimenter noted whether any of the lamps on the front of the vehicle were on, and if so, made a judgment whether they were standard headlamps, fog lamps, or parking lamps. Additionally, if the fog lamps were not on, the experimenter made a judgment concerning the presence of (unlit) fog lamps. The experimenter was seated in the front passenger seat of a mid-sized sedan. This survey included cars, vans, pick-up trucks, and large trucks.

Criteria used. The decision about whether fog lamps (as opposed to headlamps) were energized was based on the following aspects: lower mounting height, more inboard lateral position, lower intensity, and smaller area. The experimenters that did the coding of the lamps felt reasonably confident that they would not have mistaken other supplemental lamps (such as auxiliary driving lamps), for fog lamps or standard (low beam) headlamps. Furthermore, other supplemental lamps are rather rare.

Route. The survey was performed in a rural area northeast of Ann Arbor. The data were collected mostly on two-lane roadways. (On four-lane roadways, only the vehicles in the adjacent oncoming lane were surveyed.) All of the roads involved undivided traffic with little or no street lighting.

Environmental conditions. The survey was performed during both daytime and nighttime hours. Furthermore, each ambient lighting condition was surveyed under three atmospheric conditions: clear (no precipitation), moderate rain, and moderate-to-heavy fog. Data were also collected in daytime during light-to-moderate fog. Thus, there was a total of seven test conditions.

Results

The results are shown in Table 2 (daytime) and Table 3 (nighttime).

[1] This person was unavailable during one test session that involved rain during nighttime. Instead, the coding during this session was performed by a different lighting engineer (the same person who noted the installation of fog lamps in Survey 1).

Table 2
Usage during daytime conditions.

	Clear[1]	Moderate rain[2]	Light-to-moderate fog[3]	Moderate-to-heavy fog[4]
Both headlamps and fog lamps on (%)	0.0	1.1	4.7	5.4
Fog lamps on only (%)	0.4	0.0	0.2	0.5
Headlamps on; fog lamps installed (%)	0.4	6.5	6.3	3.9
Headlamps off; fog lamps installed (%)	13.6	3.0	4.7	2.1
Headlamps on; fog lamps not installed (%)	4.7	63.1	56.4	69.9
Headlamps off; fog lamps not installed (%)	80.7	20.6	24.6	12.7
Parking lamps on only (%)	0.0	5.4	2.6	5.4
Uncertain (%)	0.2	0.3	0.5	0.2
Total fog lamps installed (%)[5]	14.4	10.6	15.9	11.8
Fog lamps on of fog lamps installed (%)	2.8	10.4	30.8	50.0
Total vehicles (n)	487	369	427	883

[1]May 30, 1996: 8:00 - 9:00 A.M.

[2]June 6, 1996: 9:20 - 10:20 A.M.

[3]August 22, 1996: 6:45 A.M. - 7:40 A.M.

[4]June 19, 1996: 6:40 - 7:40 A.M. (a light drizzle on a part of the route)

[5]A sum of the top four entries in each column.

Table 3
Usage during nighttime conditions.

	Clear[1]	Moderate rain[2]	Moderate-to-heavy fog[4]
Both headlamps and fog lamps on (%)	7.8	8.0	8.3
Fog lamps on only (%)	0.0	0.0	0.0
Headlamps on; fog lamps installed (%)	4.4	4.7	5.4
Headlamps off; fog lamps installed (%)	0.0	0.0	0.0
Headlamps on; fog lamps not installed (%)	86.9	87.3	85.9
Headlamps off; fog lamps not installed (%)	0.0	0.0	0.0
Parking lamps on only (%)	0.0	0.0	0.0
Uncertain (%)	1.0	0.0	0.5
Total fog lamps installed (%)[4]	12.1	12.7	13.7
Fog lamps on of fog lamps installed (%)	64.5	63.0	60.6
Total vehicles (n)	206	275	205

[1]May 29, 1996: 10:00 - 11:00 P.M. & May 30, 1996: 11:00 - 11:45 P.M.

[2]September 21, 1996: 8:30 - 10:00 P.M.

[3]June 18, 1996: 10:00 - 11:45 P.M.

[4]A sum of the top four entries in each column.

Discussion

The goal of this study was to provide information about the frequency of installation and use of fog lamps. Two surveys were performed. In the first one, installation of fog lamps was estimated by a survey of parked vehicles in the parking lots of two large shopping centers in Ann Arbor. The installation rates of fog lamps in the two shopping centers were 9.9% and 21.5%, respectively. The higher rate was obtained at the shopping center frequented, on the average, by more affluent customers.

The second survey studied the usage of fog lamps during daytime and nighttime, under clear, rainy, or foggy conditions. In this survey, an observer in a moving vehicle noted the types of lamps that were energized on the fronts of oncoming vehicles, and whether fog lamps were present at all.

The results indicate that, during daytime, the usage rate of fog lamps increases as atmospheric conditions worsen. Of vehicles that had fog lamps installed, 2.7% of them had the fog lamps energized during clear conditions, 10.4% during moderate rain, 30.8% during light-to-moderate fog, and 50% during moderate-to-heavy fog. Because fog lamps (and for that matter any lamps) are unlikely to increase the user's ability to see during daytime, this pattern of usage probably reflects a desire on the part of the users to compensate for the decreased conspicuity of their vehicles in adverse conditions. Conversely, this pattern of results is unlikely to reflect a desire on the part of the drivers to increase the illumination ahead, because, as pointed out by Koth et al. (1978) "daylight fog driving difficulties do not include the lack of illumination" (p. 35).

When fog lamps were on during daytime, they were used primarily in conjunction with standard headlamps (90.2%) rather than by themselves (9.8%).

A somewhat different picture emerges from the nighttime data. During nighttime the usage was virtually unaffected by atmospheric conditions, being always about 63%. (The actual percentages of installed fog lamps used were 64.5% for clear weather, 63% for moderate rain, and 60.6% for moderate-to-heavy fog.) This pattern suggests that during nighttime, drivers use fog lamps to enhance the visibility provided by their headlamps. In other words, the fog lamps are being used as supplements to the current low beams, and their usage is not increased during fog or rain. This is consistent with the fact that none of the vehicles encountered during the nighttime used fog lamps without using the standard headlamps. In turn, the usage of fog lamps with standard headlamps is consistent with SAE Standard J583, and apparently also with the laws of the State of Michigan.

One possible interpretation of the fact that the nighttime usage of fog lamps is as high during clear weather as it is during inclement weather is that current low beams are perceived by drivers to be deficient, and that fog lamps help in remedying some of this deficiency. In other words, the implication is that current low beams are perceived to be deficient in the coverage of those areas that fog lamps do cover well (e.g., foreground, wide spread). A slightly different interpretation is that drivers may always like more light, no matter where it is.

During the survey of usage, installation rates of fog lamps were also estimated. Although this task was easier during daytime than during nighttime, the resulting rates were comparable (13.2% during daytime and 12.8% during nighttime). Combined with the data from Survey 1 (9.9% - 21.5%), the best overall estimate is that the current installation rate of fog lamps in southeast Michigan is about 13%.

The present data indicate that during nighttime drivers use fog lamps only with standard headlamps, and thereby follow the intent of SAE Standard J583 (Society of Automotive Engineers, 1993) and of many state laws (including Michigan's). This raises the issue of the optimal design of fog lamps. Turning on fog lamps without turning off standard headlamps does not reduce some of the problems with fog (e.g., back scatter). Consequently, this pattern of usage might limit the potential benefits that could be achieved in heavy fog with well-designed fog lamps used without standard headlamps.

Conclusions

(1) The best estimate of the current frequency of installation of fog lamps in southeast Michigan is about 13%.

(2) During daytime, the usage of fog lamps increased with deterioration in atmospheric conditions, with the usage reaching 50% of all installed fog lamps during moderate-to-heavy fog. This indicates that, during daytime, drivers adjust the usage of their lamps in response to atmospheric conditions, probably more to increase the conspicuity of their own vehicle than to illuminate the road ahead.

(3) During nighttime, the usage of fog lamps was rather high (around 63% of fog lamps installed). However, the usage does not appear to be influenced by the presence of fog or rain. This implies that, during nighttime, fog lamps are used to supplement low beams in general, rather than to provide lighting adapted to atmospheric conditions. In turn, this suggests that current low beams are perceived by drivers to be deficient in the coverage of those areas that fog lamps do cover well (e.g., foreground, wide spread).

(4) When fog lamps were used during daytime, they were seldom used alone, without standard headlamps. During nighttime, fog lamps were never used alone. This pattern of nighttime usage is consistent with SAE Standard J583 (Society of Automotive Engineers, 1993), and with the intent of the laws of the State of Michigan. However, this pattern of usage might limit the potential benefits that could be achieved in heavy fog with well-designed fog lamps used without standard headlamps.

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